Chapter A10: Methods for Estimating Commercial Fishing Benefits

INTRODUCTION

Commercial fisheries can be adversely impacted by impingement and entrainment (I&E) and many other stressors. Because commercially landed fish are exchanged in markets with observable prices and quantities, it may seem as if estimating the economic value of losses due to I&E (or the economic value of the benefits of reducing I&E) would be relatively straightforward. However, many complicating conceptual and empirical issues pose significant challenges to estimating the change in economic surplus from changes in the number of commercially targeted fish.

This chapter provides an overview of these issues, and indicates how EPA is considering methods for estimating the change in commercial fisheries-related economic surplus associated with the section 316(b) regulation. This chapter includes a review of the concept of economic surplus, and describes the theory and empirical evidence on how readily observable dockside prices and quantities may relate to the economic welfare measures of producer and consumer surplus that are suitable for a benefit-cost assessment. This chapter also provides an overview of the commercial fishery sector, including an assessment of several relevant fishery stocks, trends and patterns of how the commercial fishing sector operates, and issues of commercial fisheries management and how they affect the analysis of economic welfare measures.

A10-1 OVERVIEW OF THE COMMERCIAL FISHERY SECTOR

In estimating the effects of increased fish populations as a result of reduced I&E losses, it is important to understand who is affected. First and foremost, there are the commercial watermen, the individuals engaged in fish harvesting. These watermen typically haul their catch to established dockside wholesale markets, where they sell their catch to processors or wholesalers. Processors package or can the fish so that they can be sold as food products for people, or as pet and animal feed, or as oils and meals for various other uses. Wholesalers often resell fish to retailers (e.g., grocery stores), restaurants, or final consumers (households).

The market and welfare impacts of a change in commercial fishery harvests can be traced through a series of economic agents — individuals and businesses — that are linked through a series of "tiered markets." Through these economic relationships between the various levels of buyers and sellers, the final value of the fish product (e.g., a family dinner) creates economic signals (e.g., prices) that carry back through the various intermediate parties to the watermen who actually engage in the harvest. Additionally, beneficial changes in the commercial fishery may encourage watermen to purchase more fishing gear, fuel, and vessel repairs, which will benefit suppliers (the businesses that supply these goods and services), although such purchases from input suppliers would not typically be estimated as part of benefits.

A10-1.1 Commercial Watermen

Commercial watermen include the individuals supplying the labor and/or capital (e.g., fishing vessels) engaged in the harvesting of fish. These watermen typically haul their catch to established dockside wholesale markets, where they sell their catch to processors or wholesalers. The transactions between the watermen and these intermediate buyers provide observable market quantities and prices of dockside landings, and it is these data that serve as a starting point for estimating changes in economic surplus.

Commercial fishing is often a demanding and risky occupation. However, commercial anglers often find great satisfaction in their jobs and lifestyles. Additional detail on the economic and noneconomic aspects of commercial fishing is provided in several of the sections that follow, including a discussion of the nonmonetary benefits of commercial fishing (section A10-10).

A10-1.2 Processors, Wholesalers, and Other Middlemen

Dockside transactions typically involve buyers for whom the fish are an input to their production or economic activity. For example, processors convert raw fish into various types of final or intermediate products, which they then sell to other entities (e.g., retailers of canned or frozen fish products, or commercial or industrial entities that rely on fish oil as a production input). Wholesalers may serve as middlemen between the watermen who harvest the fish and those who will use the fish as production inputs or to retail vendors (e.g., supermarkets). Depending on the market and the type of fish, there may be numerous economic actors and layers between the commercial watermen who caught the fish and the final consumer who eats or otherwise uses the fish product.

A10-1.3 Final Consumers

After passing through perhaps several intermediate buyers and sellers, the fish (or fish products) ultimately end up with a final consumer (typically a household). This final consumption may take the form of a fish dinner prepared at home or purchased in a restaurant. Final consumption may also be in the form of food products served to household pets, or as part of a nonfood product that relies on fish parts or oils as an input to production.

A10-2 THE ROLE OF FISHING REGULATIONS AND REGULATORY PARTICIPANTS

Transactions in the fishery sector are often affected by various levels of fishery management regulations. Nearshore fishing (ocean and estuary fishing less than 3 miles from shore) and Great Lakes fishing are primarily regulated by State, Interstate, and Tribal entities. The content and relative strength of State laws affecting ocean fishing vary from state to state.

The regulated nature of many fisheries affects the manner in which the impacts and economic benefits of the section 316(b) regulation should be evaluated. For example, if the impacted fisheries were perfectly competitive with open access (i.e., no property rights or fishery regulations), then all economic rents, surplus, and profits associated with the resource would be driven to zero at the margin. However, where fisheries are regulated or in other ways depart from the neoclassical assumptions of perfectly competitive markets, there are rents and surplus that will be affected by changes in I&E. These economic considerations are addressed later in this chapter.

The primary Federal laws affecting commercial fishing in U.S. ocean territory are the Magnuson Fishery Conservation and Management Act of 1976 and the Sustainable Fisheries Act (SFA) of 1996 (the SFA amended the 1976 act and renamed it the Magnuson-Stevens Fishery Conservation and Management Act). The purpose of the 1976 act was to establish a U.S. exclusive economic zone that ranges from 3 to 200 miles offshore, and to create eight regional fishery councils to manage the living marine resources within that area. These councils comprised "commercial and recreational fishermen,

marine scientists and State and Federal fisheries managers, who combine their knowledge to prepare Fishery Management Plans (FMPs) for stocks of finfish, shellfish and crustaceans. In developing these FMPs the Councils use the most recent scientific assessments of the ecosystems involved with special consideration of the requirements of marine mammals, sea turtles and other protected resources" (NMFS, 2002c). The SFA amended the law to include numerous provisions requiring science, management, and conservation action by the National Marine Fisheries Service (NMFS) (NMFS, 2002f).

The eight fishery management councils created by the 1976 act have regulatory authority within the eight regions. They receive technical and scientific support from the National Oceanic and Atmospheric Administration (NOAA), NMFS Fisheries Science Centers, which are organized into the following regions: Alaska, Northeast, Northwest, Southeast, and Southwest. Table A10-1 presents how the regions used for this analysis fit into the fishery management council regions and other fishery regions defined by NMFS.

Table A10-1: Regional Designation of Fisheries						
Section 316(b) Phase II Region	States	NMFS Science Center	NMFS Marine Recreation Region	NMFS Commercial Region	Fishery Management Council (FMC)	Large Regions Reported in *Our Living Oceans* (NMFS, 1999b)
North Atlantic	Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island	Northeast	North Atlantic	New England	New England	Northeast
Mid-Atlantic	New York, New Jersey, Delaware, Maryland, District of Columbia, Virginia	Northeast	Mid-Atlantic	Chesapeake Mid-Atlantic	Mid-Atlantic	Northeast
South Atlantic	North Carolina, South Carolina, Georgia, Florida (Atlantic Coast)	Southeast	South Atlantic	South Atlantic	South Atlantic (NC in Mid-Atlantic)	Southeast
Gulf of Mexico	Florida (Gulf Coast), Alabama, Mississippi, Louisiana, Texas	Southeast	Gulf of Mexico	Gulf	Gulf of Mexico	Southeast
Northern California	California, north of San Luis Obispo/Santa Barbara county border	Southwest	Northern California	Pacific Coast	Pacific	Pacific Coast
Southern California	California, south of San Luis Obispo/Santa Barbara county border	Southwest	Southern California	California	Pacific	Pacific Coast
Great Lakes	Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, New York	Northeast	na	Great Lakes	na	na

A10-3 OVERVIEW OF U.S. COMMERCIAL FISHERIES

In estimating the benefits of reducing I&E losses, it is important to understand how increased fish populations may affect stocks in different fisheries. Where stocks are thriving, a small increase in the number of individual fish affected by I&E may not be noticed, but where stocks are already depleted the marginal impact of a small increase may be much more important.

Many fisheries in the United States tend to be heavily fished. In the mid-1900s, many U.S. fisheries were over-fished, some to the point of near collapse (NMFS, 1999b, 2001a; U.S. Bureau of Labor Statistics, 2002). The situation currently is showing some improvement slowly because of recent management efforts mandated by Magnuson-Stevens Act and other regulations. However, many of the current restrictions on fishing have not been in place long enough to have a dramatic impact on fisheries.

Table A10-2 shows the utilization rate of fisheries in the United States by region. The status reported is obtained from *Our Living Oceans* (NMFS, 1999b). The regions for which fish status are reported in NMFS (1999b), and in Table A10-2, are larger than those used in the section 316(b) Phase II regional analysis. The Northeast region comprises both the North Atlantic and the Mid-Atlantic regions for the analysis; the Southeast region in the report includes the South Atlantic and Gulf of Mexico regions; and the Pacific Coast region includes the Northern California and Southern California regions as well as Oregon and Washington.

Table A10-2: Utilization of U.S. Ocean and Nearshore Fisheries by Region in 1999					
Our Living Oceans Region[a]	# Fisheries with Known Status	# Fisheries with Unknown Status	# Under-Utilized	# Fully Utilized	# Over-Utilized
Alaska	43	8	10	33	0
Northeast	55	15	4	15	36
Pacific Coast	55	11	12	37	6
Southeast	34	35	2	15	17
Western Pacific	20	7	8	9	3
Total	207	76	36	109	62
% of Total Known			17%	53%	30%

[a] The Northeast region includes the North Atlantic and Mid-Atlantic regions; the Pacific Coast region includes the Northern and Southern California regions, as well as Oregon and Washington; and the Southeast includes the South Atlantic and Gulf of Mexico regions. The Alaska and Western Pacific regions are not included in the Phase II CWIS benefit-cost analysis, but are included here for comparison.

Source: NMFS, 1999b.

Based on the NMFS definitions, a fishery is considered to be producing at a less than optimal level if its recent average yield (RAY)[1] is less than the estimated long-term potential yield (LTPY).[2] This can occur as a result of either under-utilization of the fishery or collapse of the fish stock. These data indicate that a majority, 53 percent, of the ocean and nearshore fisheries with known status, were fully utilized in 1999. Approximately 30 percent of these fisheries are identified as over-utilized. For more than a third of the fisheries, the status is unknown.

The three regions most affected by the section 316(b) Phase II regulations[3] — Northeast, Pacific Coast, and Southeast — are home to 144 fisheries, or 69 percent of the total fisheries in the United States. Of these, 83 had known status in 1999; a greater percentage of fisheries in these three regions are of "known" status relative to the status of all fisheries. A higher proportion, 40 percent, of the fisheries in the three regions of interest are over-utilized compared to 30 percent for the United States as a whole. In addition, a higher proportion are under-utilized (35 percent in the three regions, versus 17 percent in the United States). The Northeast and Southeast both have high rates of over-fishing, approximately 65 percent and 50 percent, respectively. The rate of over-fishing on the Pacific Coast is much lower, with just over 10 percent of fisheries listed as being over-utilized.

Table A10-3 shows the overall production of U.S. fisheries by region. In total, the annual RAY has been over 12 million metric tons, with Alaska and the Western Pacific providing nearly two-thirds of the catch. Because of under-utilization in some fisheries and over-fishing in others, the total RAY in the United States is only 60 percent of the estimated LTPY.

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[1] RAY is measured as "reported fishery landings averaged for the most recent 3-year period of workable data, usually 1995-1997" (NMFS, 1999b, p. 4).

[2] LTPY is "the maximum long-term average catch that can be achieved from the resource. This term is analogous to the concept of maximum sustainable yield (MSY) in fisheries science" (NMFS, 1999b, p. 5). LTPY may not be the yield that maximizes surplus rents.

[3] Of the 550 total in-scope Phase II facilities, fewer than 1 percent are located in the Alaska and Western Pacific regions: 1 is located in Alaska, 3 are in Hawaii.

Table A10-3: Productivity of U.S. Regional Fisheries in 1999 (million metric tons)						
Our Living Oceans Regions[a]	Total Long-Term Potential Yield (LTPY)	Total Current Potential Yield (CPY)		Total Recent Average Yield (RAY)		
		CPY	% of LTPY	RAY	% of LTPY	% of CPY
Alaska	4.47	3.52	78.7%	2.51	56.1%	71.3%
Northeast	1.59	1.35	85.2%	0.89	55.7%	65.4%
Pacific Coast	1.04	0.85	81.9%	0.62	59.7%	72.9%
Southeast	1.50	1.15	76.7%	1.16	76.8%	100.2%
Western Pacific	3.44	3.44	100.1%	2.05	59.6%	59.6%
TOTAL	12.04	10.32	85.7%	7.22	60.0%	70.0%

[a] The Northeast region includes the North Atlantic and Mid-Atlantic regions; the Pacific Coast region includes the Northern and Southern California regions, as well as Oregon and Washington; the Southeast includes the South Atlantic and Gulf of Mexico regions. The Alaska and Western Pacific regions are not included in the Phase II CWIS benefit-cost analysis, but are included here for comparison.

Source: NMFS, 1999b.

The three regions directly affected by the Phase II regulations currently produce 2.67 million metric tons of fish, which is about 37 percent of the U.S. total. Within these regions, fisheries in the Southeast tend to be producing closest to their current and long-term potential. The RAY in the Southeast is very close to the current potential yield (CPY),[4] and is closer to the LTPY than any other region. In the Northeast region, where many fisheries are over-utilized, and in the Pacific region, where many fisheries are utilized to full capacity, the RAY is less than 60 percent of the LTPY and only about 70 percent of the CPY.

More detailed information on the status of individual species affected by I&E appears in the regional analyses presented in the Notice of Data Availability (NODA).

A10-4 PRICES, QUANTITIES, GROSS REVENUE, AND ECONOMIC SURPLUS

Dockside landings and revenues are relatively easy to observe, and readily available from NMFS. These data can be used to develop a rough estimate of the value of increased commercial catch. However, it is not always easy to interpret these data properly in estimating benefits. First, there are some empirical issues about whether the data accurately reflect the full market value of the commercial catch. Second, simply applying an average price to a change in catch does not account for a potential price response to the change in catch. Third, even if the price effect is accounted for, change in gross revenue is not necessarily the right conceptual or empirical basis for estimating benefits from reduced I&E. This section addresses these key issues.

A10-4.1 Accuracy of Price and Quantity Data

While the commercial landings data available from NMFS are the most comprehensive data available at the national and regional levels, the data may not fully capture the economic value of the commercial catch in the United States. As with any large-scale data collection effort, there are potential limitations such as database overlap and human error. Additional reasons the data may not fully capture the economic value of the commercial catch are varied and include, but are not limited to, the following:

▸ Fishermen often receive noncash payments for their catch. Crutchfield et al. (1982) noted that "the full amount of the payment to fishermen should include the value of boat storage, financing, food, fuel, and other non-price benefits that are often provided to fishermen by processors. These are clearly part of the overall 'price,' but are very difficult to measure, since they are not generally applicable to all fishermen equally and are not observed as part of dockside prices."

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[4] CPY is measured as "the potential catch that can be taken depending on the current stock abundance and prevailing ecosystem considerations" (NMFS, 1999b, p. 4).

▸ Some fishermen may sell their catch illegally. There are three main reasons why illegal transactions occur:
   •   To circumvent quantity restrictions (quotas) on landings allowed under fishery management rules.
   •   To avoid or reduce taxes by having a reported income less than true earnings.
   •   To reduce profit sharing, boat owners have been know to negotiate a lower price with the buyer and then recover part of their loss "in secret" so they do not have to share the entire profit with the crew.

▸ Some species are recorded inaccurately. Seafood dealers fill out the reports for commercial landings and may mislabel a species or not specifically identify the species — for example, entering "rockfish" instead of "blue rockfish." In this example the landings data for blue rockfish would under-estimate total landings, while data for "other rockfish" would be over-estimated (David Sutherland, NMFS, Fisheries Statistics and Economics Division, personal communication, November 4, 2002).

▸ Federal law prohibits reporting confidential data that would distinguish individual producers or otherwise cause a competitive disadvantage. These "confidential landings" are entered as "unclassified" data (e.g., finfishes, unc.) and do not distinguish individual species. Although most summarized landings are not confidential, species summary data may under-report actual landings if some of those landings have been confidential and therefore were not reported by individual species (NMFS, 2002b).

▸ Landings data are combined from nine databases that overlap spatially and temporally, and although they are carefully monitored for double-counting, some overlap may go unnoticed (NMFS, 2002b).

## A10-4.2 The Impact of Potential Price Effects

A key issue in this analysis is whether the change in fishery conditions associated with regulatory options will be sufficiently large to generate price changes in the relevant fishery markets:

▸ If the estimated changes in commercial landings are so small relative to the applicable markets that no price change of consequence is anticipated (as appears to be the case in all regions included in this analysis), then the approach to estimating benefits becomes relatively simple. As will be developed later in this chapter, this is because the change in revenues becomes straightforward to estimate (i.e., the estimated change in quantity landed times the original price). Further, with no change in price, there is a fairly transparent relationship between the change in revenues and the change in economic surplus measures that are suitable for a benefits assessment (i.e., there is no change in consumer surplus, and the change in producer surplus may be equivalent to a percentage of or even equal to the change in revenues).

▸ If changes in landings are such that a price change is anticipated, then the conceptual and empirical analysis becomes more complicated. As detailed in greater depth later in this chapter, a price change makes it more difficult to estimate changes in gross revenues (in fact the change in revenues may be either positive or negative, depending on the relative elasticity of demand). Further, a change in price is anticipated to generate changes in both producer and consumer surplus, and there are numerous complex factors to be considered in assessing these changes in welfare (e.g., some of the gain in consumer surplus will reflect a transfer away from producer surplus, the overall change in producer surplus may be positive or negative, and the relationship between these measures of surplus and the estimated market revenues is much less transparent than in the case where price is reasonably constant).

As discussed later in this chapter, in all the regional analyses performed for the final rule the change in estimated harvest is small relative to the applicable market and EPA has assumed that there would be no significant change in price. The issues with estimating changes in revenues and surplus are then relatively straightforward. It may be the case in future rulemakings, however, that price changes are likely to apply in some markets. Therefore, this chapter provides additional discussion of conceptual and empirical issues that may arise if a price change scenario may be relevant in future analyses.

A10-4.3 Key Concepts Applicable to the Analysis of Revenues and Surplus

Before progressing into the details of defining and measuring surplus and revenues, or discussing further why prices may change and how one might estimate by how much, it is important to first establish some basic economic concepts relative to markets and measures of welfare. Figure A10-1 depicts a simple market for a typical economic good, with demand (labeled as line D) downward sloping to reflect what economists refer to as decreasing marginal utility, and supply (line S) upward sloping to reflect increasing marginal costs. There are numerous reasons why the market for commercial fish often differs in important ways from the typical market depicted in the figure. Commercial fisheries are considered renewable natural

Figure A10-1: Market for Typical Economic Good
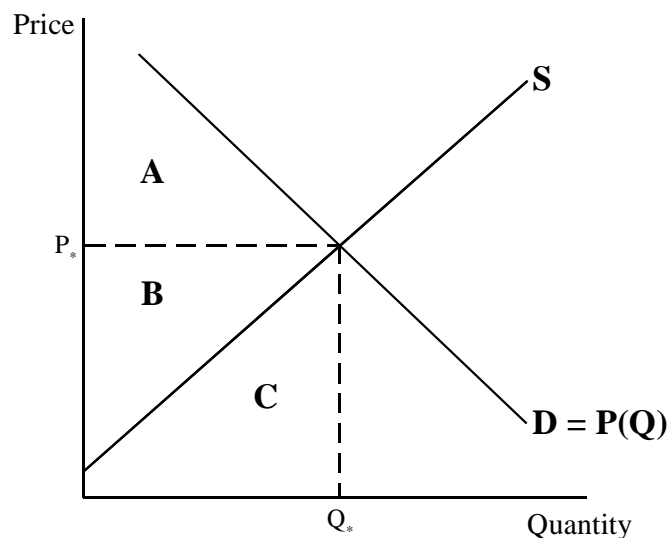
resources whereby supply is limited by ecological constraints. As a consequence, fisheries markets deviate from the traditional neoclassical view of fully competitive markets due to the impacts of open access, the socially desirable need to maximize resource rents, the corresponding need for regulations that limit catch or prevent the entry of fishermen (suppliers), and the possibility that costs may not increase in the relevant range of changes to fishery conditions. Such issues that are discussed later in the chapter. Nonetheless, to help introduce some core concepts, we begin with the standard neoclassical depiction of a market as depicted in the figure.

An equilibrium is established where supply and demand intersect, such that Q_* reflects the quantity of good exchanged and P_* reflects the market clearing price (i.e., the price at which the quantity supplied is equal to the quantity demanded). The gross revenues in this market (the sum total paid by consumers and the sum total received by sellers) are equal to P_* multiplied by Q_*, which in the figure is depicted by the rectangle made up of areas B plus C.

While the level of total (gross) revenues is of interest, it is not the same as the amount of benefit (economic welfare) that is generated by this market, which is measured by what is referred to as economic surplus (see sections A10-5.1 and A10-5.2 for further discussion of concepts related to economic surplus). Economic surplus consists of the consumer surplus generated (which is depicted by area A) plus the producer surplus generated (depicted as area B). Consumer surplus reflects the amount by which willingness-to-pay (WTP) (as reflected by the demand curve) exceeds the market-clearing price for each quantity exchanged up to Q_* (i.e., it reflects the degree by which consumers obtained the traded commodity at a price below what the good was worth to them). Likewise, producer surplus reflects the extent to which suppliers realized revenues above and beyond the marginal cost of producing some of the units (up to Q_*). Beyond Q_*, there is neither additional consumer nor producer surplus to be gained — at the margin, all the surplus has been extracted and there is no additional surplus to be gained by adding more output to the market.

Now suppose there is a change that increases the amount of a key input to production, such that the more bountiful input is now available at a lower cost to suppliers than before (e.g., when increasing the amount of locally harvestable fish makes it easier to catch a given number of fish). This could result in an outward shift in supply (a decrease in the marginal cost of producing any given quantity of the good). This is depicted in Figure A10-2, where supply shifts from S_0 to S_1. With the increased supply, a new market clearing price emerges at P_1 (which is lower than the original P_*), and the quantity exchanged increases from Q_* to Q_1.

Figure A10-2: Increased Supply in Typical Economic Market
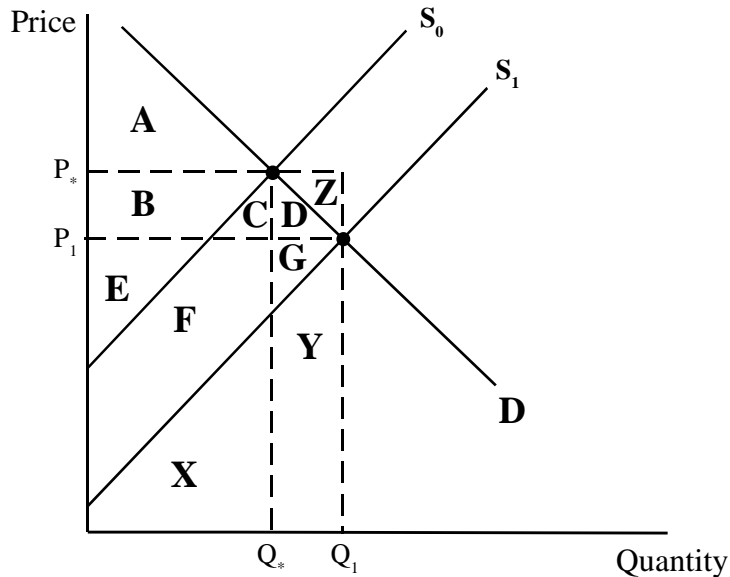
These changes in the quantity exchanged and the market clearing price make it somewhat complex to envision how (and by how much) gross revenues and economic surplus measures may change as a consequence of the shift in supply. Using Figure A10-2 as a guide:

▸ Under the original supply conditions (S_0) consumer surplus had been area A, but it has now increased to A + B + C + D. Therefore, consumer surplus has increased by an amount depicted by areas B + C + D.

▸ Producer surplus had been area B + E before the supply shift, but becomes E + F + G after the shift in supply. Hence the change in producer surplus is depicted as areas F + G - B.
  • Note that area B is subtracted from producer surplus but added to consumer surplus — i.e., it represents a transfer of surplus from producers to consumers when supply shifts outward and prices decline.
  • Also note that consumer surplus has increased by more than the transfer of area B from producers; the additional consumer surplus (above and beyond the transfer) is depicted by the amount C + D.
  • Finally, note that the change in producer surplus might be positive or negative, depending on whether the addition of F + G outweighs the loss of B (assuming the supply curves are parallel).

▸ The total change in economic surplus (consumer plus producer surplus) therefore equals C + D + F + G.

▸ Revenues had been P_* times Q_* (areas B + C + E + F + X), but now becomes P_1 times Q_1 (areas E + F + X + G + Y). The change in revenues thus becomes (G + Y) - (B + C).
  • Note that the change in revenue can be positive or negative, depending on whether G + Y is greater than or less than B + C.
  • Also note that if one does not know by how much the price will decrease, and relies on the original price (P_*) to estimate the change in revenues, then the change in revenues would be over-estimated as P_* times (Q_1 - Q_*), which is equivalent to the areas G + Y + D + Z.
  • If the change in revenues is estimated relying on the original price level (P_*) when in fact the new price becomes P_1, then the amount by which the change in revenues will be over-estimated would be B + C + D + Z.

Even though the illustration above relies on a relatively simple depiction of a market that adheres to the basic economic assumptions and conditions of perfect competition, it reveals how complex the analysis can become if there is an anticipated change in price when supply is increased. The analysis can become even more complex when fishery-related deviations from the assumptions of open access perfect competition are considered.

A10-4.4 Estimating Changes in Price (as May Be Applicable)

One key observation from the illustration above is the importance of predicting the change in price, because relying on the baseline price can lead to potential errors. Correct estimation of the change in price of fish as a result of the regulation requires two pieces of information: the expected change in the commercial catch, and the relationship between demand for fish and the price of fish. Ideally, a demand curve would be estimated for the market for each fish species in each regional market. The level of effort required to model demand in every market is not feasible for this analysis. However, if reasonable, empirically based assumptions can be made for the price elasticity of demand for fish in each region, the change in price can be accurately estimated.

The price elasticity of demand for a good measures the percentage change in demand in response to a percentage change in price. If the price elasticity of demand for fish is assumed to be -2 over the relevant portion of the demand function, then a 1 percent *increase* in price creates a 2 percent *decrease* in the quantity demanded. Essentially, this determines the shape of the demand curve because it indicates how demand responds to a change in price. The inverse of the price elasticity of demand can be used to estimate the change in price as a result of a change in the quantity demanded. If the price elasticity of demand is assumed to be -2, the inverse is $1/-2 = -0.5$. This would imply that a 1 percent *increase* in demand would correspond to a 0.5 percent *decrease* in price.

For example, in Figure A10-2, if Q_* is equal to 10,000 pounds of fish per year and reductions in I&E are expected to add 500 pounds of fish to the annual catch, Q_1 will equal 10,500 per year. This is a 5 percent increase in the quantity of fish supplied to the market. In response to the increase in supply, price will need to decrease from P_* to P_1. To clear the market, the quantity demanded would need to increase until Q_1 is also the quantity of fish demanded. If the price elasticity of demand for fish in this market is known to be approximately -2, then the inverse of the price elasticity of demand is -0.5 and, as described above, the expected change in price necessary to clear the market would be 5% x -0.5 = -2.5%. If P_* equals $1.00 per pound, then P_1 will equal $0.975 per pound, and the change in gross revenues will be (10,500 × $0.975) - (10,000 × $1.00) = $237.50. This represents a 2.375 percent increase in gross revenues for commercial fishermen in this market.

A variety of sources in the economics literature provide estimates of the price elasticity of demand for fish. In this analysis, EPA has assumed that the changes in supply of fish as a result of reduced I&E will not be large enough to create a significant change in price (see discussion below describing regional results). Therefore, assumptions about price elasticity are not necessary in this case. In future analyses if there are markets in which the estimated change in harvest is predicted to be large enough to generate a price change of consequence, EPA will revisit this issue in light of information available in the literature.

A10-5 ECONOMIC SURPLUS

Even if the change in gross revenue is measured accurately and potential price effects (if any) are accounted for, changes in gross revenues are not generally considered to be a true measure of economic benefits. According to broadly accepted principles of microeconomics, benefits should be expressed in terms of economic surplus to consumers and producers.

A10-5.1 Consumer Surplus

To understand consumer surplus, consider the following illustration. Suppose a seafood lover goes to a fish market and pays $A for a salmon for a tasty dinner. She pays $A because that is the current market price. However, she would have been willing to pay a lot more than $A, if necessary. The maximum she would have paid for the salmon is $B. The difference between $B and $A represents an additional benefit to the consumer. When this benefit is summed across all consumers in the market, it is called consumer surplus.

Figure A10-3 shows one possible representation of a market for fish. The demand curve, P(F), shows the aggregate demand that would prevail in the market (F) at each price level (P).[5,6] The curve F^1 is the quantity of fish supplied to the market by fishermen. Equilibrium is attained a the point where P(F) equals F^1. Under these conditions, the price is P^1. In this case the total amount paid by consumers for fish is equal to $P^1 \times F^1$, which is equal to the area of the boxes U + V + W in the graph. The extra benefit to consumers, i.e., the consumer surplus, is equal to the area of the triangle T.[7]

Figure A10-3: Conceptual Model of Benefits from an Increase in Fish Catch
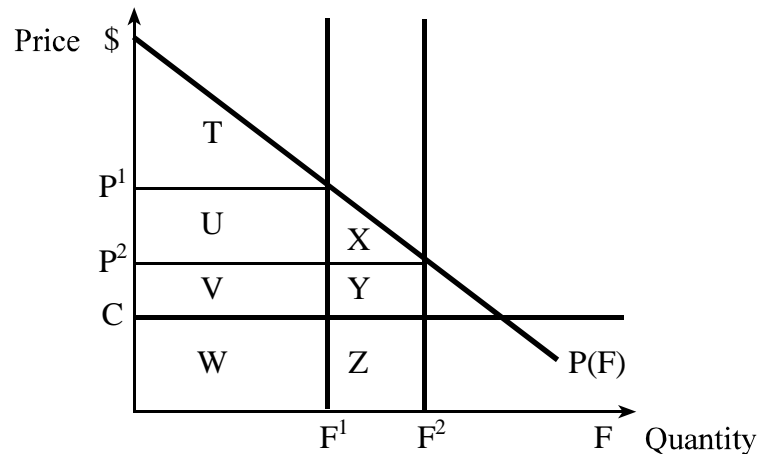
Source: Bishop and Holt (2003).

If the quantity of fish available to the market increases from F^1 to F^2, then the price decreases to P^2. This changes the total amount paid by consumers to $P^2 \times F^2$, which is equal to the area of the boxes V + W + Y + Z, and increases the consumer surplus to be equal to the area of the triangle T + U + X.

A10-5.2 Producer Surplus

In the example above, there is also a producer surplus that accrues to the fish seller. When the fish market sold the salmon to our consumer, it sold it for $A because that was the market price. However, it is likely that it cost less than $A to supply the salmon. If $C is the cost to supply the fish, then the market earns a profit of $A minus $C per fish. This profit is akin to the economic concept of producer surplus.[8]

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[5] Note that in the graph the quantity supplied, curves F^1 and F^2, is assumed to be constant under a given set of conditions. This assumption allows for a simplified case to be presented in the figure. An assumption of constant supply is more appropriate for a short-term analysis or for an analysis of a fishery regulated via quotas. Section A10-6 offers a discussion of the case where the supply curve is upward sloping.

[6] In this simplified illustration P(F) is really an inverse demand curve since it determines price as a function of quantity, F. The distinction is not of vital importance here.

[7] Note that Figure A10-3 is a highly simplified characterization of benefits derived from a commercial fishery, where the goal is to maximize producer surplus and consumer surplus. Figure A10-3 is drawn from Bishop and Holt (2003), who indicate that P(F) represents a general equilibrium demand function, accounting for markets downstream of harvesters, and that the welfare triangle (area T in Figure A10-3) represents consumer surplus plus post-harvest rents. F_1 is the supply of fish under a fixed, optimal quota before the Phase II rule and F_2 is the supply after the Phase II rule takes effect. A more complete interpretation of the graph in the context of renewable resources also reveals that costs for the harvester (e.g., fishing fleet) are equal to the area W (for a quota equal to F_1) and that area U + V is equal to the rents potentially captured by the harvester at F_1.

[8] Producer surplus equals economic profit minus the opportunity cost of the owner's resources invested in the fishery enterprise (see section A10-8 for additional details).

In Figure A10-3, the line C represents a simplified representation of the cost to the producer of supplying a pound of fish.[9] When the supply of fish is equal to F^1, the producers sell F^1 pounds of fish at a price of P^1. The difference between P^1 and C is the producer surplus that accrues to producers for each pound of fish.[10] Total producer surplus realized by producers is equal to $(P^1 - C) \times F^1$. In the example, this producer surplus is equal to the area of U + V. The area W is the amount that producers pay to their suppliers if the harvest equals F^1. In the example presented here, W might be the amount that the fish market paid to a fishing boat for the salmon plus the costs of operating the market.

When supply increases to F^2, the producers sell F^2 pounds of fish at a price of P^2. The total cost to produce F^2 increases from W to W + Z. The total producer surplus changes from U + V to V + Y.[11]

In this simple example, where C is assumed to be constant, the producer surplus earned by producers is equal for all units of F produced. If C increases as F increases, however, some of the producer surplus per unit will be eaten away by increased costs. In the figure, this would be seen as a decrease in the areas of V and Y and an increase in the areas of W and Z as a greater share of the revenues from the sale of the catch go to cover costs.

Table A10-3 is a graphical representation of a single market. In the real world, a fishing boat captain will sell the boat's catch to a processor, who sells processed fish to fish wholesalers, who in turn sells fish to retailers, who may sell fish directly to a consumer or to a restaurant, which will sell fish to a consumer. There will be consumer and producer surplus in each of these markets.[12] As a result, it is conceptually inaccurate to estimate the change in the quantity of fish harvested, multiply by the price per pound, and call this change in gross revenue the total benefits of the regulation.

The sections of this chapter that follow detail methods used in the final analysis of commercial fishing benefits attributable to the Phase II regulations. This involves three basic steps: estimating the increase in pounds of commercial catch under the rule, estimating the gross value of the increased catch, and estimating the increase in producer surplus as a proportion of increased gross value. If the rule were expected to have a greater impact on markets, an additional step would be estimating the increase in consumer surplus across all affected markets as a proportion of increased gross value. The appropriate methods to use depend on whether or not a price change is anticipated; hence the methods are presented according to these two possible scenarios.

A10-6 REGIONAL RESULTS: A CONTEXT OF NO ANTICIPATED CHANGE IN PRICE

As shown in Table A10-4, the proposed regulatory option is expected to result in small changes in commercial landings and gross dockside revenues for the North Atlantic and Northern California regions. The total landings and total value of landings of commercial species are estimated to increase by much less than 1 percent in most regions. The exceptions are the Mid-Atlantic and California (just over 1 percent), and the Great Lakes (about 3 percent). Nationwide, the value of total commercial harvest is expected to increase by less than 0.5 percent as a result of the rule.

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[9] In this case average cost is assumed to equal marginal cost at C and the marginal cost is assumed constant. Note that this is a simplification used here only to assist with the discussion. For example, the section 316(b) rulemaking might lead to a small decrease in cost per unit of fish caught. Also, if marginal cost were assumed to be upward sloping, the figure would more closely resemble the familiar graph of supply and demand with an upward-sloping supply curve, as depicted in Figure A10-2.

[10] Note that economists usually assume that C includes the opportunity cost of investing and working in commercial fishing. Thus, producer surplus is profit earned above and beyond normal profit. In a perfectly competitive market, when economic profit is being earned, it induces more producers to join the market until producer surplus is zero. However, many commercial fisheries are no longer allowing open access to all fishermen, thus it is realistic to assume that a level of producer surplus greater than zero is attainable in many U.S. commercial fisheries. In the case of managed fisheries, $(P^1 - C)$ can be referred to as rent.

[11] Note that the producer surplus may be smaller at quantity F^2 than at F^1, depending on whether U is bigger than Y. The relative sizes of U and Y depend on the slope of P(F). When the P(F) curve is less steep, i.e., when demand is more price elastic, Y will be larger compared to U. When the P(F) curve is steeper, i.e., when demand is more price inelastic, Y will be smaller compared to U. Changes in producer surplus may be negative with increased harvest if demand is sufficiently inelastic.

[12] As described in section A10-7 and Bishop and Holt (2003), the total consumer surplus accumulated through tiered markets can be estimated from a general equilibrium demand function (but not from a more typical single market partial equilibrium demand curve).

Table A10-4: Expected Increase in Commercial Harvest Resulting From Proposed Rule						
	Average Annual Harvest 1993-2001 (million pounds)[a]	**Expected Increase Attributable to Rule**		**Average Annual Gross Revenues 1993-2001 (million 2002$)[a]**	**Expected Increase Attributable to Rule**	
		Million Pounds	**Percent**		**Value (2002$)**	**Percent**
North Atlantic	610	0.2	0.03%	595	0.2	0.03%
Mid-Atlantic	913	25.3	2.77%	350	4.6	1.32%
South Atlantic	246	3.5	1.41%	203	0.6	0.30%
Gulf of Mexico	1,742	3.6	0.21%	784	2.1	0.27%
California	556	2.4	0.43%	148	1.7	1.15%
Great Lakes	26	0.8	2.99%	18	0.5	3.07%
Inland[b]	---	---	---	---	---	---
Total[c]	4,093	35.7	0.87%	2,098	9.8	0.46%

[a] *Source: NMFS, 2003a.* Annual Commercial Landing Statistics, http://www.st.nmfs.gov/commercial/landings/annual_landings.html.
[b] Inland facilities are assumed to impact recreational fisheries only. Hawaii benefit estimates are based on estimates of benefits for all coastal facilities (i.e., North Atlantic, Mid Atlantic, South Atlantic, Gulf of Mexico, California).
[c] Total expected increases are a simple sum of estimated benefits for 540 in-scope facilities with available survey data. These estimates do not include 11 in-scope facilities for which data was unavailable or 3 in-scope facilities in Hawaii for which EPA did not estimate benefits.

While some species may experience larger increases in annual harvest and value of harvest, such modest overall changes in landings are not expected to greatly influence markets for the fish. Thus, it seems reasonable to presume that there will be no appreciable impacts on wholesale or retail fish prices. Under such a scenario of no price impacts, economic theory indicates that all changes in economic welfare will be confined to changes in producer surplus (i.e., changes in consumer and related post-harvest surplus will be zero). The benefits estimation issue then can be confined to examining producer surplus, and the core empirical and conceptual issue becomes how the change in producer surplus relates to estimates of added gross revenues, when prices remain constant.

A10-6.1 Producer Surplus as a Percentage of Gross Revenues: Assuming No Change in Prices

Given the potential for increases in producer surplus for the harvest sector (including rents to harvesters) under conditions where fish price does not change, EPA has relied on estimates derived from the literature of the percentage or fraction of gross revenue change as a proxy for changes in producer surplus. There are two relevant cases to consider: the case when fisheries are not regulated and the case when they are regulated with quotas or restrictive permits.

a. Unregulated fisheries

In an unregulated fishery, a reduction in I&E will lead to an increase in the stock of fish. This will decrease the marginal cost of catching more fish, creating the possibility for fishermen to earn economic rents and increasing producer surplus. According to basic microeconomic principles, in a competitive market these economic rents will attract additional fishing effort in one of two ways: either existing fishermen will exert greater effort or new fishermen will enter the market (or both). In either case, fishing effort theoretically will increase until a new equilibrium is reached where economic rents are equal to zero. In this case, there may be economic benefits to commercial fishermen in the short term, but in the long run producer surplus will be zero. Thus, in an unregulated fishery economic theory suggests that the long-run change in producer surplus will be 0 percent of the change in gross revenues.

b. Regulated fisheries

The story is different in a fishery that is regulated such that harvests are sustainable and reflect efforts to maximize resource rents. A reduction in I&E also leads to an increase in the stock of fish, which in turn leads to increases in harvest. In this case, however, there are lasting benefits to commercial fishermen.

As an example, assume that quotas are the regulatory instrument and that quotas increase in response to reduced I&E, and that the supply curve (as represented by a marginal cost curve) shifts as a result of increased stock, then we can relate change in producer surplus to change in gross revenue using Figure A10-4. Producer surplus, before the increase in stock and change in quota, is equal to area A. Producer surplus after increase in stock and change in quota is equal to area $(A + B + D + E)$. Change in producer surplus is therefore equal to area $(B + D + E)$.

Figure A10-4: Surplus in a Regulated Fishery
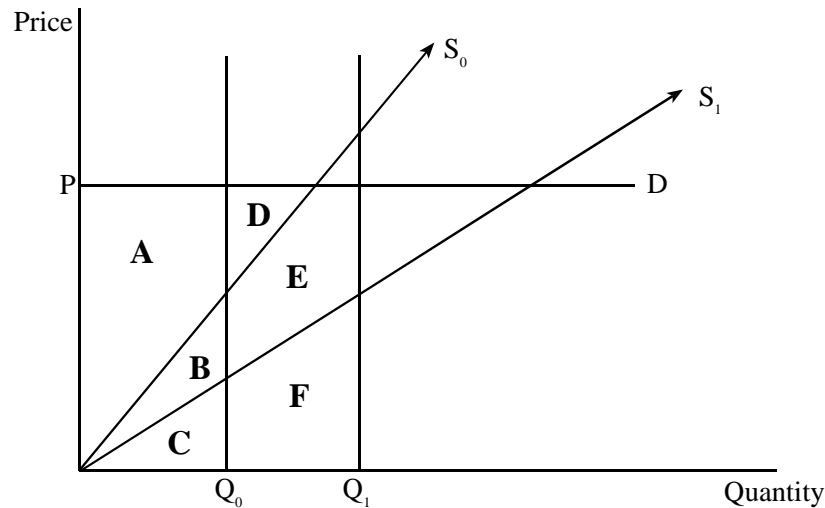
Three scenarios can be used to show how a change in revenue may over- or under-estimate change in producer surplus:

1. If $B < F$, then change in revenue over-estimates change in producer surplus.
2. If $B = F$, then change in revenue approximates change in producer surplus.
3. $B > F$, then change in revenue under-estimates change in producer surplus.

Note that if the first scenario prevails, then some fraction of gross revenue may be more suitable as a reliable proxy for change in producer surplus when price is assumed constant. If the marginal cost of supplying the extra fish for Q_1 is minimal or close to zero, then the second or third scenario prevails, and 100 percent or more of the change in revenue may serve as a reliable proxy for change in producer surplus.

A10-6.2 Conclusions on Surplus When No Change in Price is Anticipated

Various scenarios may arise when fishery conditions improve such that supply shifts outward, but not enough to generate any price change of consequence. In such cases, there is no anticipated change in post-harvest surplus to consumers or other post-harvest entities, because reduction in price is required to generate such surplus improvements. Hence, the change in economic welfare is limited to changes in producer surplus under these conditions.

As shown in the previous section, estimates of changes in dockside revenues become, under some scenarios, equivalent to the change in producer surplus. Hence, the change in gross revenues can be used as a proxy to estimate of the change in producer surplus for the regional analyses.[13] EPA also recognizes that under some of the possible scenarios that may arise when there is a quota-governed market, the full change in revenues (as estimated through a projected change in landings but no price change) might overstate the change in producer surplus. However, if dockside prices and/or dockside landings (quantities) are understated — as may often be the case — then the change in surplus will be understated in most scenarios by the estimated change in gross revenues.

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[13] This would be consistent with EPA's guidelines (U.S. EPA, 2000). The guidelines describe options for estimating ecological benefits for fisheries, and note that "if changes in service flows are small, current market prices can be used as a proxy for expected benefit . . . a change in the commercial fish catch might be valued using the market price for the affected species."

EPA's analysis of commercial fishery benefits relies on the premise that the change in producer surplus is only a fraction of the projected change in revenues. EPA has assumed a range of 0 percent to 40 percent of the estimated gross revenue changes as a means of estimating the change in producer surplus. The lower estimate of 0 percent represents the case of an unregulated fishery, as well as the lower bound identified in the literature. The range is based the discussion above and on a review of empirical literature (restricted to only those studies that compared producer surplus to gross revenue) that is described in greater detail in section A10-8.[14]

A10-7 SURPLUS ESTIMATION UNDER SCENARIOS IN WHICH PRICE MAY CHANGE

In the preceding section, the discussion was limited to cases in which no notable change in price was anticipated. These scenarios appear reasonable for very small improvements in fishery conditions, which is relevant for the regional analyses. If the estimated impacts were larger, as may be the case in other analyses, it may be inappropriate to assume that there will be no price effects in any commercial fishery markets. To ensure a complete treatment of the relevant economic theory, this section discusses the conceptual and empirical basis to estimate economic surplus (i.e., benefits) in instances where price changes are more likely to arise.

A10-7.1 Neoclassical Economic Perspective on the Market and Economic Welfare

Figure A10-5 portrays a standard, neoclassical economic depiction of a market, with demand downward sloping and supply upward sloping to reflect increasing marginal costs. There are several reasons why this neoclassical depiction may not be directly revealing or applicable to the commercial fisheries market, as discussed later in this chapter. But for the moment, Figure A10-5 provides a useful starting point for considering how the measures of economic benefit — the sum of producer and consumer surplus — might change due to a policy that shifts the supply curve outward from S_0 to S_1.

Figure A10-5: Neoclassical Model
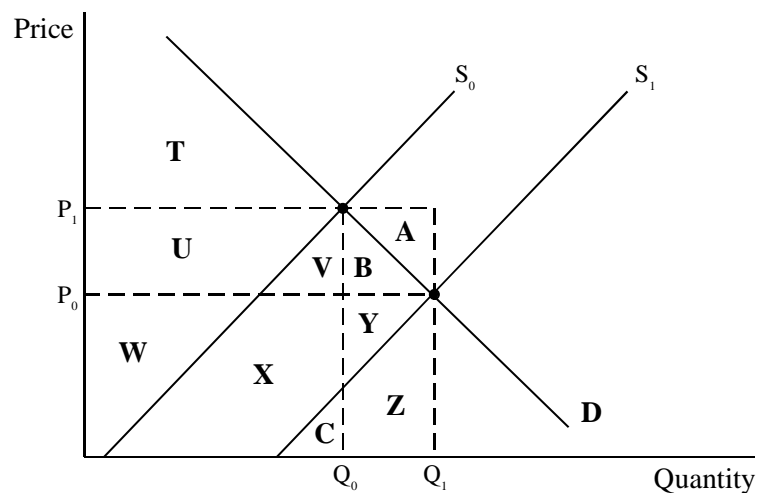
At baseline, producer surplus is depicted by areas U + W, consumer surplus by area T, and gross revenues by areas U + V + W + X + C. With an outward shift in the supply curve to S_1, we observe:

▸   Producer surplus becomes W + X + Y, hence the change in producer surplus is (W + X + Y) - (U + W), which is equal to X + Y - U.

▸ Consumer surplus becomes T + U + V + B, hence the change in consumer surplus (which previously had been area T alone) becomes U + V + B.

▸ Total change in surplus (the sum of changes in consumer and producer surplus) is therefore equal to areas X + Y + V + B.

▸ Gross revenues become W + X + Y + Z + C, hence the change in revenues becomes (W + X + Y + Z + C) minus (U + V + W + X + C), which equals (Y + Z) - (U + V).

There are several observations to make based on the above. First, note that the area U is instrumental in the change of all three measures. Area U is a positive component of the change in consumer (post-harvest) surplus, but it is subtracted from baseline producer surplus to obtain a measure of the change in that measure of welfare. Hence, in the neoclassical market model, part of the gain in consumer surplus is, in effect, a transfer from producer surplus. Area U reflects this conceptual transfer of surplus, and any empirical effort to estimate changes in surplus needs to ensure that if area U is included in the estimate of post-harvest surplus, the producer surplus estimate should be made net of area U to ensure no double counting.[15]

Another noteworthy observation from the above neoclassical characterization is that, under some circumstances, the change in revenues may be zero or even negative (depending on how area Y + Z compares to area U + V). Likewise the change in producer surplus can be positive or negative (depending on how X + Y compares to area U); with the transfer of area U from producer to consumer surplus, there are still positive net gains in producer surplus if X + Y > U.

A10-7.2 Issues in Estimating Changes in Welfare

The discussion above regarding welfare measures — and how they change with shifts in supply within the neoclassical framework — is fairly complex, even in its simplest form. To estimate such changes in welfare as may arise from the section 316(b) regulation, the problem becomes even more complicated. Some of the empirical and conceptual complications are discussed here.

In an expedited regulatory analysis that must cover a broad range of fish species across locations and fishery markets that span the nation, EPA must rely on readily applicable generalized approaches (rather than more detailed, market-specific assessments) to estimate changes in welfare. Hence, as noted earlier in this chapter, EPA must rely on readily estimated changes in gross revenues and from there infer potential changes in post-harvest (consumer) and producer surplus. In turn, there are several issues associated with how to implement an expedited approach to accomplish this.

First, there is the issue of how to estimate the change in gross revenues. These changes in revenues are the product of the projected changes in fish harvests times observed baseline market prices. Thus, EPA can readily obtain an estimate comparable to the area Y + Z + A + B in Figure A10-5. This is the approach contemplated by the Agency for this rulemaking to handle the case in which prices change. To more suitably capture the impact of a price change, in future analyses EPA may attempt to apply an applicable estimate of price elasticity to obtain an estimate that better reflects the true measure of the change in gross revenues (i.e., areas Y + Z - U - V in Figure A10-5).

Second, there is the issue of how to infer changes in post-harvest (consumer) surplus based on changes in revenues. The approach described by Bishop and Holt (2003), described in greater detail in section A10-9, is specifically designed to examine this benefits transfer issue. Their empirical research — limited to date to some regions and fisheries (e.g., the Great Lakes) — suggests that the changes in post-harvest surplus may be approximated by the estimated change in gross revenues (where the latter is based on holding price constant at baseline levels). This method may also be revisited by EPA in future analyses.

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[15] Later in this chapter an approach developed by Bishop and Holt (2003) to estimating post-harvest surplus as depicted by areas U + V + B is described. Also, note that if the fishery in question is being conducted under open access, this means that rents to the resource are zero or very close it. Suppose furthermore that in this particular case other rents (e.g., rents to scarce fishing skills and knowledge) are also zero. Now suppose that section 316(b) regulations are imposed on power plants, causing an increase in the harvest of fish. The catch increases, but any effects in rents to the resource are dissipated by entry. The effect of the regulation is to increase consumer surplus by an amount comparable to areas U + V + B in Figure A10-5, but there is no offsetting decline in producer surplus because there was no producer surplus in the first place.

Third, there are a series of issues associated with how to estimate the change in producer surplus. Estimating the change in producer surplus under a scenario in which market forces produce a price change is a challenging exercise for a number of reasons, including:

▸ Many commercial fishery markets do not adhere to the usual assumptions of the neoclassical model because of regulations that establish harvest quotas and/or restrict entry through a permit system. These regulations typically are instituted to protect stocks that have been or are at risk of being over-fished. There also may be nonregulatory barriers to entry that affect this market, such as the high fixed costs and specialized knowledge and skill set required to effectively compete in some fisheries.

▸ Barriers to entry, regardless of the source, can have a profound impact on the economic welfare analysis. For example, the neoclassical model of open access would have rents driven to zero, but it is more likely in regulated markets (or a nonregulated market with economic barriers to entry) that there are positive rents accruing from the fishery resource (not to mention rents that accrue as well to specialized fishing skills and knowledge).[16]

▸ Empirical evidence regarding the magnitude of producer surplus is limited (especially for inferring a relationship with gross revenues). These data, presented later in this chapter, suggest producer surplus may be from 0 percent to 40 percent of gross revenues. However, interpreting these data properly is challenging, for a number of reasons:

• Available empirical data pertain to average producer surplus, and EPA's regulatory analysis must instead address changes in producer surplus at the margin.

• The portion of producer surplus that is transferred to consumers when there is a price reduction (represented by area U in Figure A10-5) should not be double-counted if it is captured in the estimate of post-harvest surplus and also in the estimated change in producer surplus. Since area U is included in the Bishop-Holt analysis of changes in post-harvest surplus, one needs to ensure that area U is not included in (e.g., has been netted out of) the applicable estimate of the change in producer surplus.

• The limited empirical data from the literature that estimates producer surplus and gross revenues for fisheries can be expanded to include studies with data on "normal profits." However, these estimates of normal profits need to be adjusted downward in a logical manner to provide the more suitable producer surplus estimate. Later in this chapter some empirical evidence is provided to indicate the potential magnitude of such an adjustment.

These issues are discussed at greater length later in the chapter, but it is important to address them here because of the manner in which the departure from the neoclassical model affects how to interpret estimates of average producer surplus relative to changes expected at the margin. For example, marginal costs (MC) for commercial watermen may be minimal for a small increase in landings arising from a small increase in harvestable fish — for small increases in numbers of fish suitable for harvest in an area, small increases in harvest are likely to be realized with minimal added operating expense (i.e., MC at or near zero). This might arise where the watermen fill their quotas more easily, or exert essentially the same level of effort but come back with a few more fish. Where fishing effort and hence fishing costs would not change much, benefits (producer surplus) would equal the change in total revenue or be very close to it. For larger changes, marginal and average costs could shift down.

This has implications when interpreting the empirical literature available on producer surplus as a percentage of gross revenues. The standard neoclassical model always asserts increasing MC in the relevant range, so that producer surplus approaches zero with additional increments in landings. But for the type of situation that applies to section 316(b) — i.e., with a small change in the harvestable number of fish — and given the nature of the commercial fishery (e.g., high barriers to entry due to quotas or high fixed costs), the context is likely to reflect a situation in which costs decrease (e.g., a shift downward in MC, and perhaps MC that are at or near zero). If so, then the argument that the average estimate for producer surplus overstates the marginal value does not hold (in fact, the opposite may be true — average surplus could be less than producer surplus at the margin).

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[16] Given the highly regulated nature of many fisheries today, a wide range of producer effects is conceivable. Even where revenues decline with a reduction in price, producer surplus could increase despite the loss in revenues. This could occur if the effect on price is relatively small and the effect on costs and revenues is relatively large. The only way to know for sure is to examine producer effects in specific cases or do a benefits transfer exercise using experience in real world fisheries as a guide. Simple approaches (e.g., assuming that there is no consumer surplus because of offsetting producer effects) are not satisfactory if there are changes in prices.

A10-8 ESTIMATING PRODUCER SURPLUS

An important portion of commercial fishing benefits is the producer surplus generated by the estimated marginal increase in landings. The level of effort and data required to model supply and demand in every regional fishing market to compute producer surplus are unavailable to EPA. Various researchers, however, have developed empirical estimates that can be used to infer producer surplus for watermen based on gross revenues (landings times wholesale price). EPA reviewed the economic literature on commercial fishing to examine the available results. This body of research provides two types of data that can be used to estimate producer surplus as a percentage of gross revenues. These percentages can easily be applied to changes in gross revenues expected under the Phase II rule to estimate the changes in producer surplus expected under the Phase II rule.

The most common result reported in the literature is normal profit. A large number of studies across a variety of fisheries estimate the revenues earned and costs borne by commercial fishing operations. These results can be used to estimate normal profit. As defined here, normal profit is the standard accounting definition of profit, i.e., total revenues earned minus the costs of production (e.g., fishing equipment, fuel, boat maintenance, hired labor, bait). For example, assume a commercial fishing vessel brings in a total catch worth $100,000 in a given year. Also assume that it incurred variable material costs of $50,000 and hired labor costs of $30,000. The normal profit received by the owner would then be $20,000 ($100,000 - $50,000 - $30,000 = $20,000).

The more useful concept and result reported in the literature is producer surplus because, as described above, producer surplus is a more appropriate indicator of social welfare than is profit. Producer surplus equals normal profit minus the vessel owner's opportunity cost of participating in commercial fishing. In other words, producer surplus nets out the return to capital that the owner of a commercial fishing operation could expect to earn in another industry. Thus, producer surplus is the level of profits *above and beyond* what the owner would earn on his capital in another industry (or by investing in the stock market), and is less than or equal to normal profits. If the owner of the commercial fishing vessel in the previous example could expect to make a $1,000 return by investing his capital in another industry, then the producer surplus for this vessel owner would be $19,000 ($100,000 - $50,000 - $30,000 - $1,000 = $19,000).

While producer surplus is a preferable welfare measure, the literature review identified only four studies reporting results that can be used as direct estimates of producer surplus. Available measures of producer surplus and normal profits are reported as a percentage of gross revenue in Tables A10-5 and A10-6, respectively. Table A10-5 reports estimates of the more desirable producer surplus, and Table A10-6 reports the more common estimates of normal profits. EPA calculated these percentage values from data included in each cited study.[17] Looking at the values reported in the studies, it is clear that no single estimate of producer surplus as a percentage of gross revenue is appropriate for all regions, boat types, and species. For those studies that most closely approximate producer surplus (Table A10-5), the rough estimates of producer surplus range from 0 percent to 37 percent, with an average of approximately 23 percent. Therefore, EPA has assumed a range of 0 percent to 40 percent in the regional analyses. Note that the lower estimate of 0 percent is also consistent for the case of an unregulated fishery.

The estimates of normal profit span a wider range, with results in Table A10-6 ranging from a low of -5 percent to a high of 91.2 percent. One of the key issues for using the data on "normal profit' is whether some adjustment is reasonable to convert the ratios of normal profit to revenues into suitable estimates of the ratio of producer surplus to revenues. EPA has found limited empirical information on which to evaluate the potential adjustment factor. For example, King and Flagg (1984) provide data for California fisheries, itemizing various components of fixed and variable costs, and also providing annual revenues. Assuming that owners might be able to earn a 7 percent real rate return on all of their fixed costs that might otherwise be invested productively elsewhere, and netting these estimated returns from normal profit, the implied ratios of producer surplus to revenues are only between 0.4 percent and 2.6 percent lower than the ratios of normal profit to revenues, for the seven fishery types evaluated to date by EPA from the King and Flagg data. EPA also identified another study that contained relevant data (Larkin et al., 2000), and interpreting the data provided in similar fashion, the change in ratios is only 2.3 percent (consistent with the effect seen in King and Flagg). Because EPA identified only limited empirical evidence related to estimating an adjustment factor, the results in Table A10-6 are presented for comparative purposes only. Analysts for future rulemakings may wish to consider this issue and explore it further.

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[17] Most of the estimates in Table A10-6 are a variation of the following equation: 1 - (variable cost / gross revenue), where the variable cost includes the opportunity cost of participating in commercial fishing for the producer surplus measures.

Author(s)	Year	Geographic Area/Fishery	Analysis Year(s)	Type Boat(s)	Fish Species Sought	Producer Surplus % of Gross Revenue[a]	Notes on Study
Cleland and Bishop	1984	Michigan's Upper Great Lakes	1981	Varied	Most common: whitefish, lake trout, chubs	28%	Reported data used by EPA to calculate costs (including return to owner) as % of gross revenue — for 5 large Native American fishing operations
						35%	Reported data used by EPA to calculate costs (including return to owner) as % of gross revenue — for 11 moderately large Native American fishing operations
						27%	Reported data used by EPA to calculate costs (including return to owner) as % of gross revenue — for 36 small Native American fishing operations
Huppert and Squires	1987	U.S. Pacific coast	1984	Trawlers	Groundfish	37%	Reported results used by EPA to estimate: 1 - (profit + variable costs)/(total revenue) Estimates include return to owner as part of costs
Gilbert	1988	North-East North Island, New Zealand	1980s	Varied	Snapper	35%	Estimated economic surplus at dynamic maximum economic yield Estimates include return to owner as part of costs
		Hauraki Gulf, New Zealand	1980s	Varied	Red gurnard	20%	
		Firth of Thames, New Zealand	1980s	Varied	Yellow belly flounder	15%	
Norton et al.	1983	U.S. South Atlantic coast	1980	Varied	Striped bass	0%	Estimated producer surplus per pound of fish and revenue per pound of fish
		U.S. New England coast	1980	Varied	Striped bass	11%	

Table A10-5: Summary of Research on Commercial Fisher Producer Surplus Measures: Producer Surplus (Studies that Report Profit Estimates that Include a Return to the Owner as Part of Costs)

[a] Estimate includes returns to owners as part of costs, and thus excludes them from calculation of profit. This estimate can be considered a close proxy for producer surplus.

Author(s)	Year	Geographic Area/Fishery	Year(s) of Analysis	Type Boat(s)	Fish Species Sought	Normal Profit as % of Gross Revenue[a]	Notes on Study
Table A10-6: Summary of Research on Commercial Fisher Producer Surplus Measures: Normal Profits (Studies that _DO NOT_ Report Profit Estimates that Include a Return to the Owner as Part of Costs)						
Brown et al.	1976	Columbia River	1960s	Varied	Salmon and steelhead	90%	Citation from other literature of percentage of gross revenue that goes to total surplus in a salmon fishery
Crutchfield et al.	1982	Tazimina River (Bristol Bay, Alaska)	1970s	Varied	Salmon	85% to 90%	Authors estimate net economic value of a change in availability of salmon in a fishery with limited access and excess capacity
King and Flagg	1984	California coast	1982	Trawlers in North CA	Groundfish	67%	Reported data by fish/boat type used by EPA to calculate 1 - (variable cost / gross revenue) Costs _do not include_ return to owner
				Trawlers in South CA	Groundfish	89%	
				Trawlers	Shrimp	4%	
				Seiners	Tuna	45%	
King and Flagg	1984	California coast	1982	Seiners	Wetfish	22%	Reported data by fish/boat type used by EPA to calculate 1 - (variable cost / gross revenue) Costs _do not_ include return to owner
				Gillnetters	Herring	-5%	
				Gillnetters	Other	69%	
				Small trollers	Salmon	49%	
				Large trollers	Salmon	52%	
				Crabbers	Salmon	74%	
				Albacore	Salmon	57%	
				Longliners	Varied	89%	
				Varied: using hook & line	Varied	66%	
				Varied: using pots	Black cod	91%	
				Varied	Crab-lobster, north	74%	
King and Flagg	1984	California coast	1982	Varied	Crab-lobster, south	50%	Reported data by fish/boat type used by EPA to calculate 1 - (variable cost / gross revenue) Costs _do not_ include return to owner
				Bailboats	Varied	38%	
				Jigboats	Varied	22%	
				Diveboats	Varied	59%	
				Varied: using harpoon	Billfish	49%	

Author(s)	Year	Geographic Area/Fishery	Year(s) of Analysis	Type Boat(s)	Fish Species Sought	Normal Profit as % of Gross Revenue[a]	Notes on Study
Rettig and McCarl	1985	U.S. varied	Varied	Varied	Varied	50%	Authors review several studies and suggest that "variable costs may be approximately 50 percent of revenues for all commercial operators" Estimates do not include return to owner as part of costs
Usher	1987	Lake of the Woods, Ontario	1980-1982	Varied	Varied	28%	Reported results used by EPA to estimate: (net revenue) / (gross revenue) Estimate does not include return to owner as part of costs
Talhelm	1988	Great Lakes	1985	Varied	Varied	51%	Reported food fishery stats used by EPA to calculate: (gross value minus harvest costs) / (total value) Estimate does not include return to owner as part of costs
Larkin et al.	2000	U.S. Atlantic coast	1996	Longline	Varied, includes swordfish, tuna, sharks, and other	55%	Reported data used by EPA to calculate: (total net revenue) / (total gross revenue) Estimate does not include return to owner as part of costs

Table A10-6: Summary of Research on Commercial Fisher Producer Surplus Measures: Normal Profits (Studies that DO NOT Report Profit Estimates that Include a Return to the Owner as Part of Costs)

[a] Estimate does not include returns to owners as part of costs, and thus overstates producer surplus by that amount.

A10-9 ESTIMATING POST-HARVEST ECONOMIC SURPLUS IN TIERED MARKETS

Estimating producer surplus provides an estimate of the benefits to commercial fishermen, but significant benefits can also be expected to accrue to final consumers of fish and to commercial consumers (including processors, wholesalers, retailers, and middlemen) if the projected increase in catch is accompanied by a reduction in price. These benefits can be expected to flow through the tiered commercial fishery market (as described in section A10-1 and in Bishop and Holt, 2003).

Bishop and Holt (2003) developed an inverse demand model of six Great Lakes fisheries that they use to estimate changes in welfare as a result of changes in the level of commercial harvest. This flexible model can be used to model welfare changes under a variety of conditions in the fishery. It takes as an input the expected change in harvest and baseline gross revenues, and provides as outputs the expected change in gross revenues and change in total compensating variation (CV).

CV is the change in income that would be necessary to make consumers' total utility the same as it was before the reduction in I&E losses resulting from the Phase II rule. This is analogous to a measure of willingness to accept compensation in order to forgo the improvement. Conceptually, CV is a measure of welfare similar to consumer surplus. The key difference is that consumer surplus is calculated using the familiar demand function (or curve), which defines the quantity demanded as a function of price and income (in the simple example, Figures A10-1 and A10-2, income is assumed to be constant). CV, on the other hand, is calculated using a compensated demand function, which defines the quantity demanded as a function of price and utility. While consumer surplus and CV are generally very similar welfare measures, CV is considered to be the true measure of benefits (i.e., a more consistent indicator of utility), and consumer surplus is an approximation. The distinction between the two is a subtle point in welfare economics; the exact details are not crucial to the analysis.[18]

The key point to note is that estimates of CV from the Holt-Bishop model capture the benefits to final consumers and commercial consumers throughout the various markets in which fish are bought and resold for a given level of harvest. The model output provides a convenient way to estimate the benefits of an increase in harvest as a percentage of gross revenues, and thus a tractable way to estimate the benefits of increased catch that do not accrue to the primary producers.[19] See Holt and Bishop (2002) for further detail on the model.

For the commercial benefits estimated for the proposed rule, EPA used the results of the Holt-Bishop model, as applied to a specific Great Lakes application. These results indicated that the change in CV for the Great Lakes fisheries can be expected to be approximately 78 percent of the change in total surplus (with producer surplus equal to the remaining 22 percent). In each case study analysis at proposal, EPA applied this 22 percent estimate as a benefits transfer to all the commercial benefits estimates in the case studies developed at that time. To estimate consumer surplus from gross revenues, EPA first estimated the change in producer surplus lost at each case study facility due to I&E and then divided the producer surplus estimate by 0.22 to estimate total surplus. For example, if producer surplus was estimated to be $1,000, total surplus (producer surplus + CV) was estimated to be $1,000/0.22 = $4,545. This approach is undergoing significant revision.

Based on comments received on the commercial benefits analysis for the proposed Phase II rule, EPA worked with Dr. Bishop to re-assess the suitability of using the results from Holt and Bishop (2002) in a benefits transfer. EPA determined that the magnitude of the changes in commercial catch modeled in the Holt and Bishop paper is, in most cases, larger than the magnitude of the expected changes as a result of the Phase II regulations, and thus the benefits may be quite different. To address this issue, Bishop and Holt (2003) explore the impacts on surplus measures for more moderate changes in fishery conditions, and Bishop and Holt (2003) reports on the findings of the re-estimation of their Great Lakes model in terms that related economic surplus to levels of gross revenues.

In their recent work, Bishop and Holt (2003) observe that, as a general rule of thumb, in the fisheries they model the change in CV as a percentage of the change in gross revenues is more or less linearly related to change in catch. In other words, a 10 percent increase in catch as a result of the Phase II rule would be expected to produce an increase in CV equal to approximately a 10 percent of the change in gross revenues. As an example, if the Phase II rule increases the catch of a species by 10 percent and the gross value of the additional catch is $100,000, then the increase in CV would be $10,000.

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[18] For a more detailed discussion of the difference in consumer surplus and CV, the reader is referred to in Varian (1992, Chapters 7 and 9) or any graduate-level microeconomics text.

[19] Bishop and Holt do not estimate changes in producer surplus, and indicate such changes need to be estimated separately and then combined with post-harvest consumer surplus results.

Since no significant price changes are expected in any of the regions included in this analysis, the effective change in CV attributable to the Phase II rule is expected to be minimal. In estimating benefits, EPA has assumed the change will be $0.

A10-10 NONMONETARY BENEFITS OF COMMERCIAL FISHING

As with many activities, commercial fishing provides benefits that are not measured in the value of the catch. Fishing is hard work. It involves strenuous outdoor work, long hours, and lengthy trips to sea, often in hazardous weather conditions. Fishing is also dangerous work. "Fishing has consistently ranked as the most deadly occupation since 1992," when the Bureau of Labor Statistics (BLS) started publishing fatality rates by occupation (Drudi, 1998, p. 1). In addition, the *BLS Occupational Handbook: Fishers and Fishing Vessel Operators* (U.S. Bureau of Labor Statistics, 2002) predicts that "employment of fishers and fishing vessel operators is expected to decline through the year 2010. These occupations depend on the natural ability of fish stocks to replenish themselves through growth and reproduction, as well as on governmental regulation of fisheries. Many operations are currently at or beyond maximum sustainable yield, partially because of habitat destruction, and the number of workers who can earn an adequate income from fishing is expected to decline."

In spite of this evidence, individuals still express a desire to fish, perhaps even because of the hardships and challenges of the job. Studies on why fishermen choose to fish have determined that income is, not surprisingly, the primary reason for participating in commercial fishing. Fishermen fish to support themselves and their families, and generally earn more in fishing than they would in other occupations. There are other important factors, though, including the importance of fishing to the way of life in small, coastal towns (not unlike the importance of farming to many rural towns throughout the United States); the belief that fishing helps the U.S. economy; and identity, i.e., people opt to work in commercial fishing because it provides enjoyment and because it is an integral part of how they identify themselves psychologically and socially (Smith, 1981; Townsend, 1985; Berman et al., 1997).

Research in the economic literature indicates that some fishermen opt to remain in the fishing industry despite the ability to make higher incomes in other industries. Some economists have suggested that there exists a worker satisfaction bonus that can, at least in theory, be measured and should be included in cost-benefit analyses when making policy decisions (Anderson, 1980). One study identified in a cursory literature review of this topic also found evidence in the Alaskan fisheries that as many as 29.5 percent of all vessels across 14 fisheries from 1975 to 1980 earned net incomes that were lower than the income they could receive from selling their fishing permit. The author concluded that "this pattern of apparent losses seems to confirm much of the casual observation that is the source of speculation that non-pecuniary returns are a significant factor in commercial fishing. It is thought that these financial losses are accepted only because they are offset by non-money gains" (Karpoff, 1985).

Because the Alaskan fisheries exist under much different conditions than those in the rest of the United States, it would be a mistake to assume that nearly 30 percent of U.S. fishing vessels earn incomes less than the value of their fishing permits. However, based on the cursory review of the commercial fishing literature, there is evidence that commercial fishermen gain nonmonetary benefits from their work. Despite the existence of these nonmonetary benefits in the commercial fishing sector, there is little research that has provided defensible methods for estimating the additional nonmonetary benefits that may accrue to commercial fishermen as a result of the Phase II regulations. Thus, the omission of these nonmonetary benefits is noted here, but no estimates will be included in the benefits analyses.

A10-11 METHODS USED TO ESTIMATE COMMERCIAL FISHERY BENEFITS FROM REDUCED I&E

EPA will estimate the commercial benefits expected under the final Phase II regulations in the following steps. EPA will estimate total losses under current I&E conditions (or the total benefits of eliminating all I&E) in steps 1 through 3. Then, in step 4, EPA will apply the estimated percentage reduction in I&E to estimate the benefits expected under each regulatory option. Each step will be performed for each region in the final analysis: the North Atlantic, Mid-Atlantic, South Atlantic, Gulf of Mexico, Northern California, Southern California, Great Lakes, and the internal United States.

The steps used to estimate regional losses and benefits are as follows:

1. **Estimate losses to commercial harvest (in pounds of fish) attributable to I&E under current conditions.** EPA models these losses using the methods presented in Chapter A5 of Part A of the section 316(b) Phase II Case Study Document. Changes in these methods for the NODA and subsequent analyses are provided in the NODA (see sections on "Case Study Corrections and Clarifications" and "Impingement and Entrainment Methods"). The basic approach is to apply a linear stock to harvest assumption, such that if 10 percent of the current commercially targeted stock were harvested, then 10 percent of the commercially targeted fish lost to I&E would also have been harvested absent I&E. The percentage of fish harvested is based on data on historical fishing mortality rates.

2. **Estimate gross revenue of lost commercial catch.** The approach EPA uses to estimate the value of the commercial catch lost due to I&E relies on landings and dockside price ($/lb) as reported by NMFS for the period 1991-2001. These data are used to estimate the revenue of the lost commercial harvest under current conditions (i.e., the increase in gross revenue that would be expected if all I&E impacts were eliminated).

3. **Estimate lost economic surplus.** The conceptually suitable measure of benefits is the sum of any changes in producer and consumer surplus. The methods used for estimating the change in surplus depend on whether the physical impact on the commercial fishery market appears sufficiently small such that it is reasonable to assume there will be no appreciable price changes in the markets for the impacted fisheries.

   For the regions included in this analysis, it is reasonable to assume no change in price, which implies that the welfare change is limited to changes in producer surplus. This change in producer surplus is assumed to be equivalent to a portion of the change in gross revenues, as developed under step 2. EPA assumes a range of 0 percent to 40 percent of the gross revenue losses estimated in step 2 as a means of estimating the change in producer surplus. This is based on a review of empirical literature (restricted to only those studies that compared producer surplus to gross revenue) and is consistent with recommendations made in comments on the EPA analysis at proposal.

   EPA believes this is a conservative approach to estimating producer surplus when there is no anticipated price changes. EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000; EPA 240-R-00-003) describe options for estimating ecological benefits for fisheries, and note that "if changes in service flows are small, current market prices can be used as a proxy for expected benefit . . . a change in the commercial fish catch might be valued using the market price for the affected species." This statement indicates that 100 percent of gross revenue change, based on current prices, may be a suitable measure of value.

4. **Estimate increase in surplus attributable to the Phase II regulations.** Once the commercial surplus losses associated with I&E under baseline conditions have been estimated according to the approaches outlined in steps 2 and 3, EPA estimates the percentage reduction in I&E at each facility under each regulatory option. This analysis is conducted for each region.

A10-12 LIMITATIONS AND UNCERTAINTIES

EPA reviewed the methods used to estimate the benefits expected to accrue to producers and consumers in commercial fish markets. Based on this review and on comments received on the benefits analysis for the proposed rule, EPA is changing some of the methods used to estimated commercial benefits. EPA believes that these changes will improve the accuracy and reduce the uncertainty of the estimates.

Some uncertainties, of course, will remain. Table A10-7 summarizes the caveats, omissions, biases, and uncertainties known to affect the estimates that will be developed for the final benefits analysis.

Table A10-7: Caveats, Omissions, Biases, and Uncertainties in the Commercial Benefits Estimates		
Issue	**Impact on Benefits Estimate**	**Comments**
Change in commercial landings due to I&E	Uncertain	The economic analysis described in the chapter relies on projected changes in harvest developed using data and methods described in the NODA and elsewhere. These projected changes in harvest may be under-estimated because neither cumulative impacts of I&E over time nor interactions with other stressors are considered.
Estimates of commercial harvest losses due to I&E under current conditions not region/species specific	Uncertain	EPA estimates the impact of I&E in the case study analyses based on data provided by the facilities. The most current data available were used. However, in some cases these data are 20 years old or older. Thus, they may not reflect current conditions.
Effect of change in stocks on number of landings not considered	Uncertain	EPA assumes a linear stock to harvest relationship, that a 13 percent change in stock would have a 13 percent change in landings; this may be low or high, depending on the condition of the stocks. Region-specific fisheries regulations also will affect the validity of the linear assumption.
Effect of uncertainty in estimates of commercial landings and prices unknown	Uncertain	EPA assumes that NMFS landings data are accurate and complete. In some cases prices and/or quantities may be reported incorrectly.
Estimates of producer surplus as percentage of gross landings not region/species specific	Uncertain	EPA currently estimates that the increase in producer surplus as a result of the rule will be between 0 percent and 40 percent of the estimated change in gross revenues. The research used to develop this range is not region-specific; thus the true value may fall outside this range (higher or lower) for some regions and species.